CHAPTER 8

TRANSMISSION LINES

8.1 INTRODUCTION

Transmission lines are the guided conducting structures which are used in power distribution at low frequencies in communications. The main aim of this chapter is to provide the overall concepts of Transmission Line theory. They include:

- Transmission lines parameters: primary and secondary constants.
- Transmission line equations: input impedance, reflection coefficient.
- Expression for characteristic impedance, propagation constant, and velocity of wave propagation for various transmission lines: lossless line, distortionless line.
- Standing waves and standing wave ratio.
- Smith chart: determination of line characteristics using Smith chart.
- Transients on transmission line: bounce diagram.

8.2 TRANSMISSION LINE PARAMETERS

The equivalent circuit of a transmission line is a distributed network. This consists of cascaded sections and each section consists of a series resistance R, series inductance L, shunt capacitance C, and shunt conductance G. One section of the equivalent circuit is shown in Figure 8.1. Let us study the primary and secondary constants for transmission line.

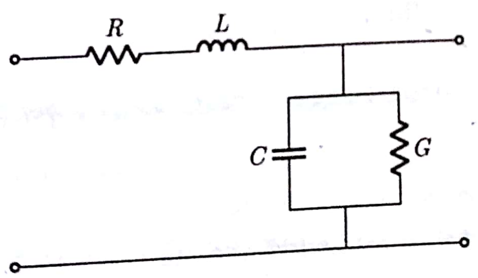

Figure 8.1: Equivalent Circuit of a Transmission Line

8.2.1 Primary Constants

The distributed parameters R, L, C, and G are called the primary constants of the transmission line. The primary constants of a transmission line are defined as follows:

1. R is defined as loop resistance per unit length of line.
2. L is defined as loop inductance per unit line length.

3. C is defined as shunt capacitance between two wires per unit length.
4. G is defined as the conductance per unit length due to the dielectric medium separating the conductors.

The values of R, L, C and G depend on the geometry of transmission line, characteristics of the dielectric material and in some cases on the frequency. For coaxial, two-wire, and planar lines, the formulae for calculating the values of R, L, G, and C are provided in Table below.

Table 8.1: Primary Constants of Transmission Lines at High Frequencies

Parameters	Coaxial Line	Two-wire Line	Planar Line
$R\,(\Omega/\text{m})$	$\frac{1}{2\pi\delta\sigma_c}\left[\frac{1}{a}+\frac{1}{b}\right]$; $(\delta << a, c-b)$	$\frac{1}{\pi a\delta\sigma_c}$; $(\delta << a)$	$\frac{2}{w\delta\sigma_c}$; $(\delta << t)$
$L\,(\text{H/m})$	$\frac{\mu}{2\pi}\ln\frac{b}{a}$	$\frac{\mu}{\pi}\cosh^{-1}\frac{d}{2a}$	$\frac{\mu d}{w}$
$G\,(\text{S/m})$	$\frac{2\pi\sigma}{\ln\frac{b}{a}}$	$\frac{\pi\sigma}{\cosh^{-1}\frac{d}{2a}}$	$\frac{\sigma w}{d}$
$C\,(\text{F/m})$	$\frac{2\pi\varepsilon}{\ln\frac{b}{a}}$	$\frac{\pi\varepsilon}{\cosh^{-1}\frac{d}{2a}}$	$\frac{\varepsilon w}{d}$; $(w << d)$

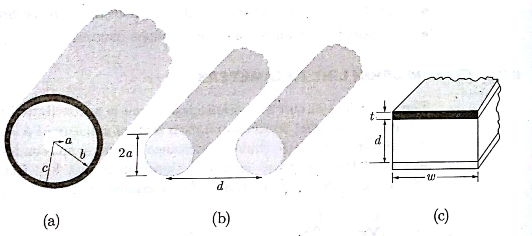

Figure 8.2: Transmission Lines: (a) Coaxial Line, (b) Two-wire Line, and (c) Planar Line

8.2.2 Secondary Constants

The secondary constants of a transmission line are

1. Propagation constant, γ
2. Characteristic impedance, z_0

1. Propagation Constant

Propagation constant of a transmission line can be defined as follows:

DEFINITION I

For a transmission line with primary constants R, L, C and G, the propagation constant is given by

$$\gamma = \sqrt{\text{series impedance} \times \text{shunt admittance}}$$

$$= \sqrt{(R+j\omega L)(G+j\omega C)}$$

DEFINITION II

In terms of attenuation constant, α and phase constant, β, the propagation constant is defined as

$$\gamma = \alpha + j\beta$$

DEFINITION III

For a transmission line, if the voltage and current at source end be V_s, I_s, and the voltage and current at load end be V_L, I_L; then the propagation constant for the transmission line is defined as

$$\gamma = 20\log_{10}\left(\frac{I_s}{I_L}\right)$$

$$= 20\log_{10}\left(\frac{V_s}{V_L}\right)\text{dB}$$

2. Characteristic Impedance

Characteristic impedance of a transmission line can be defined as follows:

DEFINITION I

For a transmission line with primary constants R, L, C and G, the characteristic impedance is defined as

$$Z_0 = \sqrt{\frac{\text{series impedance}}{\text{shunt admittance}}}$$

$$= \sqrt{\frac{R+j\omega L}{G+j\omega C}}$$

DEFINITION II

For a transmission line, if the forward voltage and forward current at any point be V_0^+, I_0^+; then the characteristic impedance of the transmission line is given by

$$Z_0 = \frac{V_0^+}{I_0^+}$$

DEFINITION III

For a transmission line, if the reflected voltage and reflected current at any point be V_0^-, I_0^-; then the characteristic impedance of the transmission line is given by

$$Z_0 = -\frac{V_0^-}{I_0^-}$$

8.3 TRANSMISSION LINE EQUATIONS

Consider a transmission line of length l as shown in Figure 8.3. If the voltage and current at any arbitrary location on the line be V and I, respectively, then the transmission line equation is defined as

$$\frac{d^2V}{dz^2} = \gamma^2 V$$

$$\frac{d^2I}{dz^2} = \gamma^2 I$$

where γ is the propagation constant. The solution of the line equations can be obtained in phasor form as

$$V_s(z) = V_0^+e^{-\gamma z} + V_0^-e^{\gamma z}$$

$$I_s(z) = I_0^+e^{-\gamma z} + I_0^-e^{\gamma z} = \frac{V_0^+}{Z_0}e^{-\gamma z} - \frac{V_0^-}{Z_0}e^{\gamma z}$$

where V_0^+ and I_0^+ are the voltage and current for forward wave travelling along $+a_z$ direction, and V_0^- and I_0^- are the voltage and current for the reflected wave travelling along $-a_z$ direction.

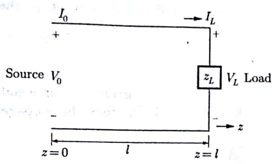

Figure 8.3: Equivalent Circuit for defining Transmission Line Equation

8.3.1 Input Impedance of Transmission Line

At source end of the transmission line, we have

$$V_0 = V_s(z=0) = V_0^+ + V_0^-$$

$$I_0 = I_s(z=0) = \frac{V_0^+ - V_0^-}{Z_0}$$

So, the input impedance of transmission line is given by

$$Z_{in} = \frac{V_s(z=0)}{I_s(z=0)} = \frac{Z_0(V_0^+ + V_0^-)}{(V_0^+ - V_0^-)}$$

The input impedance can also be expressed as

$$Z_{in} = Z_0\left[\frac{Z_L + Z_0 \tanh \gamma l}{Z_0 + Z_L \tanh \gamma l}\right]$$

where Z_0 is the characteristic impedance, l is the length of transmission line, γ is the propagation constant, and Z_L is the load impedance given by

$$Z_L = \frac{V_L}{I_L}$$

where V_L is the load voltage, and I_L is the load current defined as

$$V_L = V_s(z=l)$$

$$= V_0^+ e^{-\gamma l} + V_0^- e^{\gamma l}$$

$$I_L = I_s(z=l)$$

$$= \frac{V_0^+ e^{-\gamma l} + V_0^- e^{\gamma l}}{Z_0}$$

Following are some important points related to input impedance of transmission line.

POINTS TO REMEMBER

1. For a shorted transmission line, $Z_L = 0$, the input impedance is
$$(Z_{in})_{sc} = Z_0 \tanh \gamma l$$
2. For open circuited line, $Z_L = \infty$, the input impedance is given by
$$(Z_{in})_{oc} = Z_0 \coth \gamma l$$
3. From the above two results, we have
$$(Z_{in})_{sc}(Z_{in})_{oc} = Z_0^2$$
4. For matched line, $Z_L = Z_0$, the input impedance is
$$Z_{in} = Z_0$$

8.3.2 Reflection Coefficient

At the load terminal, the voltage reflection coefficient is defined as the ratio of voltage reflection wave to the incident wave, i.e.

$$\Gamma_L = \frac{V_0^- e^{\gamma l}}{V_0^+ e^{-\gamma l}}$$

which can be further expressed as

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}$$

The current reflection coefficient at any point on the line is the negative of the voltage reflection coefficient at that point, so we have

$$-\Gamma_L = \frac{I_0^- e^{\gamma l}}{I_0^+ e^{-\gamma l}}$$

8.4 LOSSLESS TRANSMISSION LINE

A transmission line is said to be lossless if the conductors of the line are perfect, or $\sigma_c = \infty$ and the dielectric medium between the lines is lossless, or, $\sigma_d = 0$. Some important characteristics of a lossless transmission line are given below.

8.4.1 Primary Constants of a Lossless Line

For a lossless transmission line,

1. Series resistance is zero, i.e. $R = 0$
2. Shunt conductance is zero, i.e. $G = 0$

8.4.2 Secondary Constants of a Lossless Line

Using the above condition for lossless line, we obtain a generalised expression for secondary constants as follows:

Propagation Constant

The propagation constant of a lossless transmission line is obtained as

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)} = \sqrt{(0 + j\omega L)(0 + j\omega C)}$$

$$= j\omega\sqrt{LC}$$

or $\quad \gamma = j\beta = j\omega\sqrt{LC}$

Thus, the attenuation and phase constants of transmission line is given by

$$\alpha = 0, \beta = \omega\sqrt{LC}$$

Characteristic Impedance

The characteristic impedance of a lossless transmission line is obtained as

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} = \sqrt{\frac{0 + j\omega L}{0 + j\omega C}}$$

$$= \sqrt{\frac{L}{C}}$$

8.4.3 Velocity of Wave Propagation in a Lossless Line

The velocity of propagation in a lossless transmission line is given by

$$v_p = \frac{\omega}{\beta} = \frac{1}{\sqrt{LC}}$$

8.4.4 Input Impedance of a Lossless Line

We have just derived the propagation constant for a lossless line as

So, we have

$$\gamma = j\beta$$

$$\tanh\gamma l = \tanh j\beta l = j\tan\beta l$$

Thus, the input impedance for a lossless line is obtained as

$$Z_{in} = Z_0\left[\frac{Z_L + Z_0\tanh\gamma l}{Z_0 + Z_L\tanh\gamma l}\right]$$

$$= Z_0\left[\frac{Z_L + jZ_0\tan\beta l}{Z_0 + jZ_L\tan\beta l}\right]$$

8.5 DISTORTIONLESS TRANSMISSION LINE

A transmission line is said to be distortionless when the attenuation constant, α is frequency-independent and the phase constant, β is linearly dependent on the frequency.

8.5.1 Primary Constants of a Distortionless Line

For a distortionless line, the required condition is satisfied when the primary constants are related as

$$\frac{R}{L} = \frac{G}{C}$$

8.5.2 Secondary Constants of a Distortionless Line

Using the above condition for distortionless line, we obtain a generalised expression for secondary constants as follows:

Propagation Constant

The propagation constant of a distortionless transmission line is obtained as

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)}$$

$$= \sqrt{RG\left(1 + \frac{j\omega L}{R}\right)\left(1 + \frac{j\omega C}{G}\right)}$$

$$= \sqrt{RG}\left(1 + \frac{j\omega C}{G}\right) = \alpha + j\beta$$

Thus, we obtain the attenuation and phase constants as

$$\alpha = \sqrt{RG}$$

$$\beta = \omega\sqrt{LC}$$

Characteristic Impedance

The characteristic impedance of a distortionless line is obtained as

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$= \sqrt{\frac{R(1 + j\omega L/R)}{G(1 + j\omega C/G)}}$$

$$= \sqrt{\frac{R}{G}} = \sqrt{\frac{L}{C}}$$

8.5.3 Velocity of Wave Propagation in a distortionless Line

The velocity of propagation in a distortionless transmission line is given by

$$v_p = \frac{\omega}{\beta} = \frac{1}{\sqrt{LC}}$$

The comparison between the propagation parameters of various transmission lines are given in table below.

Table 8.2: Propagation Parameters for Different Types of Lines

Parameter	General Transmission Line	Lossless Line	Distortionless Line
γ	$\sqrt{(R + j\omega L)(G + j\omega C)}$	$j\omega\sqrt{LC}$	$\sqrt{RG} + j\omega\sqrt{LC}$
α	$\left[\frac{(RG - \omega^2 LC)}{2} + \frac{\sqrt{(R^2 + \omega^2 L^2)(G^2 + \omega^2 C^2)}}{2}\right]^{1/2}$	0	$\sqrt{\frac{R}{G}}$
β	$\left[\frac{(\omega^2 LC - RG)}{2} + \frac{\sqrt{(R^2 + \omega^2 L^2)(G^2 + \omega^2 C^2)}}{2}\right]^{1/2}$	$\omega\sqrt{LC}$	$\omega\sqrt{LC}$
Z_0	$\sqrt{\frac{R + j\omega L}{G + j\omega C}}$	$\sqrt{\frac{L}{C}}$	$\sqrt{\frac{L}{C}}$ or $\sqrt{\frac{R}{G}}$
v_p	$\frac{\omega}{\beta}$	$\frac{1}{\sqrt{LC}}$	$\frac{1}{\sqrt{LC}}$

8.6 STANDING WAVES IN TRANSMISSION LINE

If the receiving end of a transmission line is not perfectly matched, there will be reflection of the voltage and current. As a consequence of reflection, a *standing wave* may be visualised as an interference between the incident signal V_0^+ at a given frequency, travelling in the forward direction, and the reflected signal V_0^-, at the same frequency, travelling in the reverse direction. *Standing wave ratio* is defined as the ratio of the maximum voltage (or current) to the minimum voltage (or current) of a line having standing waves.

$$S = \frac{V_{max}}{V_{min}} = \frac{I_{max}}{I_{min}} = \frac{1 + |\Gamma_L|}{1 - |\Gamma_L|}$$

Following are some important points about standing waves:

POINTS TO REMEMBER

1. Standing waves are so called because the wave oscillates in amplitude but never moves literally.
2. At a position 180° and multiple of that from the load $(n\frac{\lambda}{2})$, the voltage and current must have the same values they do at the load.
3. At a position 90° and odd multiple of that from the load $(n\frac{\lambda}{4})$, the voltage and current must be inverted: if the voltage is lowest and the current is highest at the load, then at 90° from the load the voltage reaches its highest value and the current reaches its lowest value at the same point.
4. No standing waves will be developed along a matched line. The voltage along the line is constant, so the matched line is also said to be flat line.

8.7 SMITH CHART

The Smith chart is basically a graphical indication of the impedance of a transmission line and of the corresponding reflection coefficient as one moves along the line. The Smith chart is constructed within a circle of unit radius ($|\Gamma| \le 1$) as shown in Figure 8.4. Γ_r and Γ_i are the real and imaginary parts of the reflection coefficient, i.e.

$$\Gamma = |\Gamma| \underline{/\theta_\Gamma} = \Gamma_r + j\Gamma_i \qquad \text{...(8.1)}$$

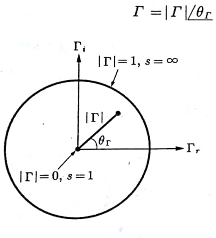

Figure 8.4: Unit Circle on which Smith Chart is Constructed

Let the normalized load impedance for the transmission line be

$$z_L = \frac{Z_L}{Z_0} = r + jx \qquad \text{...(8.2)}$$

Since, the reflection coefficient is defined as

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{\frac{Z_L}{Z_0} - 1}{\frac{Z_L}{Z_0} + 1} = \frac{z_L - 1}{z_L + 1} \qquad \text{...(8.3)}$$

So, by solving equations (8.1), (8.2), and (8.3) we get

$$z_L = r + jx = \frac{(1+\Gamma_r) + j\Gamma_i}{(1-\Gamma_r) - j\Gamma_i} \qquad \text{...(8.4)}$$

8.7.1 Constant Resistance Circles

Equating the real parts in equation (8.4), we get the expression for r-circles on Smith chart as

$$\left[\Gamma_r - \frac{r}{1+r}\right]^2 + \Gamma_i^2 = \left[\frac{1}{1+r}\right]^2$$

These circles are also called constant resistance circles. Figure 8.5(a) shows typical r-circles for a transmission line. Some important properties of r-circles are given below.

PROPERTIES OF r-CIRCLES

1. The centres of all r-circles lie on the Γ_r-axis.
2. The $r = 0$ circle having a unit radius and centred at the origin, is the largest.
3. The r-circles become progressively smaller as r increases from 0 toward ∞, ending at the ($\Gamma_r = 1, \Gamma_i = 0$) point for open circuit.
4. All r-circles pass through the ($\Gamma_r = 1, \Gamma_i = 0$) point.

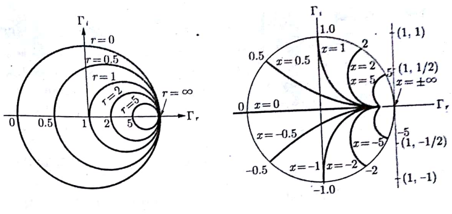

Figure 8.5: Typical Circles on Smith Chart: (a) Typical r-circles, (b) Typical x-circles

8.7.2 Constant Reactance Circles

Again, equating the imaginary parts in equation (8.4), we get the expression for x-circles as

$$[\Gamma_r - 1]^2 + \left[\Gamma_i - \frac{1}{x}\right]^2 = \left[\frac{1}{x}\right]^2$$

These circles are also called constant resistance circles. Figure 8.5(b) shows typical x-circles for a transmission line. Some important properties of x-circles are given below.

PROPERTIES OF x-CIRCLES

1. The centres of all x-circles lie on the $\Gamma_r = 1$ line; those for $x > 0$ (inductive reactance) lie above the Γ_r-axis, and those for $x < 0$ (capacitive reactance) lie below the Γ_r-axis.
2. The $x = 0$ circle becomes the Γ_r-axis.
3. The x-circles become progressively smaller as $|x|$ increases from 0 toward ∞, ending at the ($\Gamma_r = 1, \Gamma_i = 0$) point for open circuit.
4. All x-circles pass through the ($\Gamma_r = 1, \Gamma_i = 0$) point.

8.7.3 Application of Smith Chart

Smith chart can be used for the following purposes:

1. To find the normalised admittance from normalised impedance and vice-versa.
2. To find the parameters of mismatched transmission lines
3. To find the standing wave ratio for a given load impedance.
4. To find the reflection coefficient.
5. To find the input impedance of a transmission line.
6. To locate a voltage maximum on a transmission line.
7. To design stubs for impedance matching.

The methodology to determine some line characteristics using Smith chart is given below.

METHODOLOGY: TO DETERMINE THE LINE CHARACTERISTICS USING SMITH CHART

Consider the Smith chart shown in Figure 8.6. To evaluate the various characteristics of transmission line, we follow the steps given below.

Step 1: Calculate the normalised impedance using the expression

$$z_L = \frac{Z_L}{Z_0} = r_L + jx_L$$

where Z_L is the load impedance, and Z_0 is the characteristic impedance.

Step 2: Locate z_L on the Smith chart at point P where $r = r_L$ circle and $x = x_L$ circle meet.

Step 3: To get reflection coefficient (Γ), extend OP to meet $r = 0$ circle at Q. Then, measure OP and OQ. Since OQ corresponds to $\Gamma = 1$, then at P, we get

$$|\Gamma| = \frac{OP}{OQ}$$

Step 4: Read angle θ_Γ directly from the chart as the angle between OS and OP. Evaluate the reflection coefficient as

$$\Gamma = |\Gamma| \angle \theta_\Gamma$$

Step 5: To obtain standing wave ratio S, draw a circle with radius OP and centre at O. This is the constant S or $|\Gamma|$ circle. Locate point S where the circle meets the Γ_r-axis. The value of r at this point is standing wave ratio.

Step 6: To obtain input impedance, express the length of transmission line in terms of λ. Since, λ corresponds to an angular movement of 720° on the chart, obtain the angular movement in degrees corresponding to the length of transmission line. For example,

$$l = \frac{\lambda}{3} = \frac{720°}{3} = 240°$$

Step 7: Move toward the generator (in clockwise direction) 240° on the S-circle from point P to point G. At G, obtain the normalised input impedance as

$$z_{in} = r_{in} + jx_{in}$$

Step 8: Obtain the input impedance as

$$Z_{in} = Z_0 z_{in}$$

8.8 TRANSIENTS ON TRANSMISSION LINE

When a pulse generator or battery connected to a transmission line is switched on, it takes some time for the current and voltage on the line to reach steady values. This transitional period is called the transient. Transit time is defined as the time for the waves traveling in the positive direction to reach the load and interact with it, i.e.

$$T = \frac{l}{v_p}$$

where l is the length of the transmission line, and v_p is the velocity of the wave along transmission line.

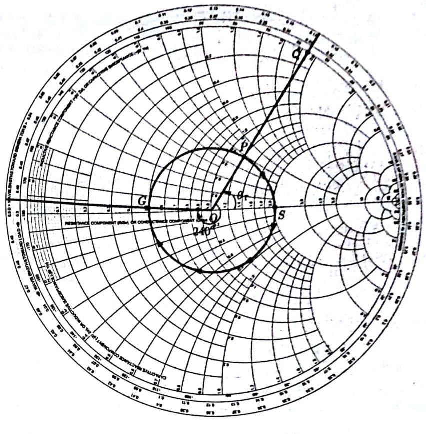

Figure 8.6: Determination of Line Characteristics using Smith Chart

8.8.1 Instantaneous Voltage and Current on Transmission Line

After T seconds, the wave reach the load. The voltage (or current) at the load is the sum of the incident and reflected voltages (or currents). Thus,

$$V(l,T) = V^+ + V^- = V_o + \Gamma_L V_o = (1 + \Gamma_L) V_o$$

and
$$I(l,T) = I^+ + I^- = I_o - \Gamma_L I_o = (1 - \Gamma_L) I_o$$

where Γ_L is the load reflection coefficient. The reflected waves $V^- = \Gamma_L V_o$ and $I^- = -\Gamma_L I_o$ travel back toward the generator in addition to the waves V_o and I_o already on the line. At time $t = 2T$, the reflected waves have reached the generator, so

$$V(0,2T) = V^+ + V^- = \Gamma_G \Gamma_L V_o + (1 + \Gamma_L) V_o$$
$$= (1 + \Gamma_L + \Gamma_G \Gamma_L) V_o$$

and
$$I(0,2T) = I^+ + I^- = -\Gamma_G(-\Gamma_L I_o) + (1 - \Gamma_L) I_o$$
$$= (1 - \Gamma_L + \Gamma_L \Gamma_G) I_o$$

where Γ_G is the generator reflection coefficient given by

$$\Gamma_G = \frac{Z_g - Z_o}{Z_g + Z_o}$$

Again the reflected waves (from the generator end) $V^+ = \Gamma_G \Gamma_L V_o$ and $I^+ = \Gamma_G \Gamma_L I_o$ propagate toward the load and the process continues until the energy of the pulse is actually absorbed by the resistors Z_g and Z_L.

8.8.2 Bounce Diagram

Instead of tracing the voltage and current waves back and forth, it is easier to keep track of the reflections using a bounce diagram. The bounce diagram consists of a zigzag line indicating the position of the voltage (or current) wave with respect to the generator end, as shown in Figure 8.7. On the bounce diagram, the voltage (or current) at any time may be determined by adding those values that appear on the diagram above that time.

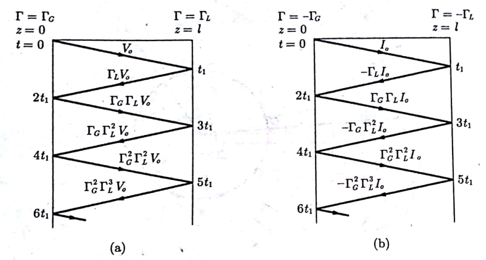

Figure 8.7: Bounce Diagram for (a) Voltage Wave, (b) Current Wave

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EXERCISE 8.1

MCQ 8.1.1 **Assertion (A) :** A sinusoidal voltage $v_i = V_0 \cos(4 \times 10^4 \pi t)$ is applied to the input terminal of a transmission line of length 20 cm such that the wave propagates with the velocity $c = 3 \times 10^8$ m/s on the line. It's output voltage will be in the same phase to the input voltage.

Reason (R) : Transmission line effects can be ignored if $\frac{l}{\lambda} \leq 0.01$.

where l is the length of transmission line and λ is the wavelength of the wave.

(A) A and R both are true and R is correct explanation of A.
(B) A and R both are true but R is not correct explanation of A.
(C) A is true but R is false
(D) A is false but R is true

MCQ 8.1.2 The space between the strips of a parallel plate transmission line is filled of a dielectric of permittivity, $\varepsilon_r = 1.3$ and conductivity, $\sigma \approx 0$. If the width of the strips is 9.6 cm and the separation between them is 0.6 cm then the line parameters G' and C' will be respectively

(A) 0, 0.02 nF/m
(B) 0.02 mS/m, 0.14 nF/m
(C) 0, 0.18 nF/m
(D) 1.8 mS/m, 0

MCQ 8.1.3 Inductance and capacitance per unit length of a lossless transmission line are 250 nH/m and 0.1 nF/m respectively. The velocity of the wave propagation and characteristic impedance of the transmission line are respectively.

(A) 2×10^8 m/s, 100 Ω
(B) 3×10^8 m/s, 50 Ω
(C) 2×10^8 m/s, 50 Ω
(D) 3×10^8 m/s, 100 Ω

MCQ 8.1.4 A transmission line operating at a frequency 6×10^8 rad/s has the parameters $R' = 0.2\,\text{k}\Omega/\text{m}$, $L' = 4\,\mu\text{H/m}$, $G' = 8\,\mu\text{S/m}$, $C' = 4\,\text{pF/m}$. The propagation constant, γ will be

(A) $(0.5 + j1.2)\,\text{m}^{-1}$
(B) $(0.10 + j2.4)\,\text{m}^{-1}$
(C) $(1.2 + j0.5)\,\text{m}^{-1}$
(D) $(2.4 + j0.10)\,\text{m}^{-1}$

MCQ 8.1.5 The parameters of a transmission line are given as $R' = 10\,\Omega/\text{m}$, $L' = 0.1\,\mu\text{H/m}$, $C' = 10\,\text{pF/m}$, $G' = 40\,\mu\text{S/m}$. If the transmission line is operating at a frequency, $\omega = 1.2 \times 10^9$ rad/s then the characteristic impedance of the line will be

(A) $50 - j2\,\Omega$
(B) $4 - j100\,\Omega$
(C) $100 - j4\,\Omega$
(D) $100 + j4\,\Omega$

MCQ 8.1.6 A parallel plate lossless transmission line consists of brass strips of width w and separated by a distance d. If both w and d are doubled then it's characteristic impedance will

(A) halved
(B) doubled
(C) not change
(D) none of these

MCQ 8.1.7 Phase velocity of voltage wave in a distortion less line having characteristic impedance, $Z_0 = 0.1\,\text{k}\Omega$ and attenuation constant, $\alpha = 10\,\text{mNP/m}$ is $v_p = 0.5 \times 10^8\,\text{m/s}$. The line parameters R' and L' will be respectively

(A) $1\,\Omega/\text{m}$, $0.5\,\text{nH/m}$
(B) $10\,\text{k}\Omega/\text{m}$, $2\,\mu\text{H/m}$
(C) $2\,\Omega/\text{m}$, $1\,\mu\text{H/m}$
(D) $1\,\Omega/\text{m}$, $2\,\mu\text{H/m}$

MCQ 8.1.8 A distortionless line has parameters $R' = 4\,\Omega/\text{m}$ and $G' = 4 \times 10^{-4}\,\text{S/m}$. The attenuation constant and characteristic impedance of the transmission line will be respectively

(A) $25\,\text{NP/m}$, $0.01\,\Omega$
(B) $100\,\text{NP/m}$, $4 \times 10^{-2}\,\Omega$
(C) $4 \times 10^{-2}\,\text{NP/m}$, $100\,\Omega$
(D) $0.01\,\text{NP/m}$, $25\,\Omega$

MCQ 8.1.9 A $150\,\Omega$ transmission line is connected to a $300\,\Omega$ resistance and to a 60 V DC source with zero internal resistance. The voltage reflection coefficients at the load end and at the source and of the transmission line are respectively

(A) -1, $1/3$
(B) -1, -1
(C) $1/3$, $1/3$
(D) $1/3$, -1

MCQ 8.1.10 A purely resistance load Z_L is connected to a $150\,\Omega$ lossless transmission line. Such that it has a voltage standing wave ratio of 3. The possible value of Z_L will be

(A) $50\,\Omega$
(B) $450\,\Omega$
(C) (A) and (B) both
(D) none of these

MCQ 8.1.11 A voltage generator with $v_g(t) = 3\cos(\pi \times 10^9 t)$ volt is applied to a $100\,\Omega$ lossless air spaced transmission line. If the line length is 10 cm and it is terminated in a load impedance $Z_L = (200 - j200)\,\Omega$ then the input impedance of the transmission line will be

(A) $(50 - j50.8)\,\Omega$
(B) $(12.5 - j12.7)\,\Omega$
(C) $(25.4 - j25)\,\Omega$
(D) $(25 - j25.4)\,\Omega$

MCQ 8.1.12 Phase velocity of a voltage wave in a transmission line of length l is v_p. If the transmission line is open circuited at one end and short circuited at the other end then the natural frequency of the oscillation of the wave will be

(A) $\frac{nv_p}{2l}$; $n = 0, 1 .... \infty$
(B) $\frac{(2n+1)v_p}{4l}$; $n = 0, 1, ... \infty$
(C) $\frac{(2n+1)v_p}{4l}$; $n = 1, 2, 3, ... \infty$
(D) $\frac{nv_p}{2l}$; $n = 1, 2, 3 ..... \infty$

MCQ 8.1.13 At an operating frequency of 500 Hz, length of a transmission line is given by $l = \lambda/4$. For the same transmission line the length at 1 kHz will be given by

(A) $l = \frac{\lambda}{8}$
(B) $l = \frac{\lambda}{4}$
(C) $l = \frac{\lambda}{2}$
(D) none of these

MCQ 8.1.14 A transmission line is operating at wavelength 'λ'. If the distance between successive voltage minima is 10 cm and distance between load and first voltage minimum is 7.5 cm then the distance between load and first voltage maxima is

(A) $\lambda/8$
(B) $3\lambda/8$
(C) $5\lambda/8$
(D) $\lambda/4$

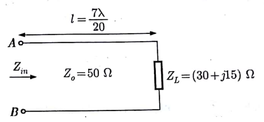
MCQ 8.1.15 A z-polarized transverse electromagnetic wave (TEM) propagating along a parallel plate transmission line filled of perfect dielectric in $+a_x$ direction. Let the electric and magnetic field of the wave be $\boldsymbol{E}$ and $\boldsymbol{H}$ respectively. Which of the following is correct relation for the fields.

(A) $\frac{\partial E_z}{\partial y} = 0$
(B) $\frac{\partial H_y}{\partial z} = 0$
(C) Both (A) and (B)
(D) none of these

MCQ 8.1.16 Distance of the first voltage maximum and first current maximum from the load on a $50\,\Omega$ lossless transmission line are respectively 4.5 cm and 1.5 cm . If the standing wave ratio on the transmission line is $S = 3$ then the load impedance connected to the transmission line will be

(A) $(90 - j120)\,\Omega$
(B) $10\,\Omega$
(C) $(30 - j40)\,\Omega$
(D) $(40 - j30)\,\Omega$

MCQ 8.1.17 Total length of $50\,\Omega$ lossless transmission line terminated in a load impedance $Z_L = (30 + j15)\,\Omega$ is $l = 7\lambda/20$ as shown in figure. The total input impedance across the terminal AB will be



(A) $(38.3 - j64.8)\,\Omega$
(B) $(19.2 - j32.4)\,\Omega$
(C) $(64.8 - j38.3)\,\Omega$
(D) $(32.4 - j19.2)\,\Omega$

MCQ 8.1.18 **Assertion (A) :** The input impedance of a quarter wavelength long lossless line terminated in a short-circuit is infinity.

Reason (R) : The input impedance at the position where the magnitude of the voltage on a distortionless line is maximum is purely real.

(A) A and R both are true and R is correct explanation of A.
(B) A and R both are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

Common Data For Q. 19 and 20 :

A voltage generator with $v_g(t) = 10\cos(8\pi \times 10^7 t - 30)$ and an internal impedance $Z_g = 30\,\Omega$ is applied to a $30\,\Omega$ lossless transmission line that has a relative permittivity $\varepsilon_r = 2.25$ and length, $l = 6\,\text{m}$.

MCQ 8.1.19 If the line is terminated in a load impedance, $Z_L = (30 - j10)\,\Omega$, then what will be the input impedance of the transmission line ?

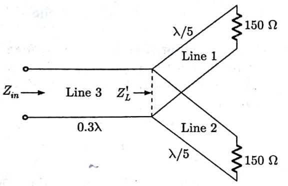
(A) $(0.05 - j0.01)\,\Omega$
(B) $(50.62 + j23.48)\,\Omega$
(C) $(92.06 - j21.80)\,\Omega$
(D) $(23.14 + j5.48)\,\Omega$

MCQ 8.1.20 The input voltage of the transmission line will be

(A) $4.4\cos(8\pi \times 10^7 t + 22.56°)$
(B) $4.4\cos(8\pi \times 10^7 t - 37.44°)\,\text{V}$
(C) $4.4\cos(8\pi \times 10^7 t - 22.56°)\,\text{V}$
(D) $4.4\cos(8\pi \times 10^7 t - 30°)\,\text{V}$

Common Data For Q. 21 and 22 :

Two equal load impedances of 150 Ω are connected in parallel through a pair of transmission line, and the combination is connected to a feed transmission lien as shown in figure. All the lines are lossless and have characteristic impedance $Z_0 = 100\,\Omega$.



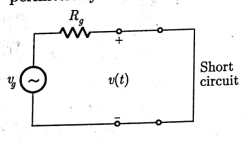
MCQ 8.1.21 The effective load impedance of feedline (Z_L') equals to
(A) $(7.04 - j17.24)\,\Omega$
(B) $(35.20 + j8.62)\,\Omega$
(C) $(35.20 - j8.62)\,\Omega$
(D) $(8.62 + j35.20)\,\Omega$

MCQ 8.1.22 The total input impedance of the feedline (line 3) will be
(A) $(2.15 - j1.13)\,\Omega$
(B) $(215.14 - j113.4)\,\Omega$
(C) $(215.14 + j113.4)\,\Omega$
(D) $(107.57 - j56.7)\,\Omega$

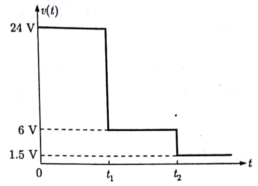
MCQ 8.1.23 A 0.3 GHz voltage generator with $V_{sg} = 150$ volt and an internal resistance $Z_g = 100\,\Omega$ is connected to a $100\,\Omega$ lossless transmission line of length $l = 0.375\,\lambda$. If the line is terminated in a load impedance $Z_L = (100 - j100)\,\Omega$ then what will be the current flowing in the load ?
(A) $0.67\cos(3\times 10^8 t - 108.4°)$
(B) $0.67\cos(6\pi\times 10^8 t - 108.4°)$
(C) $75\cos(3\times 10^8 t - 108.4°)$
(D) $0.67\cos(6\pi\times 10^8 t - 135°)$

MCQ 8.1.24 The input impedance of an infinitely long transmission line is equal to it's characteristic impedance. The transmission line will be
(A) slightly lossy
(B) lossless
(C) Distortion less
(D) (B) and (C) both

MCQ 8.1.25 At time $t = 0$ unit step voltage generator V_g with an internal resistance R_g is applied to a $100\,\Omega$ shorted transmission line filled with dielectric of permittivity $\varepsilon = 4\varepsilon_0$ as shown in figure



The voltage waveform for any time $t \geq 0$ at the sending end is sown in figure below

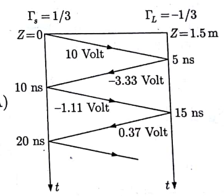


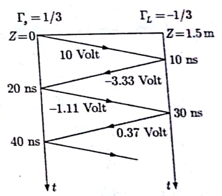
V_g and R_g will be respectively equal to
(A) 30 volt, 19.2 Ω
(B) 38.4 volt, 60 Ω
(C) 60 volt, 38.4 Ω
(D) 19.2 volt, 30 Ω

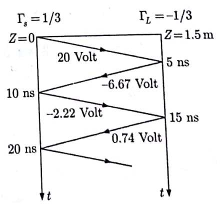
Common Data For Q. 26 and 27 :

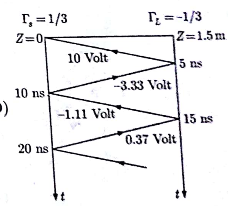
A 1.5 m section o an airspacd lossless transmission line is fed by a unit step voltage generator $V_g = 30$ volt with internal resistance $R_g = 200\,\Omega$. The transmission line is terminated in a resistive load $Z_L = 50\,\Omega$ and characterized by $Z_0 = 100\,\Omega$.

MCQ 8.1.26 The bounce diagram of the transmission line will be

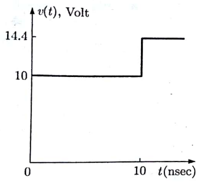
(A)


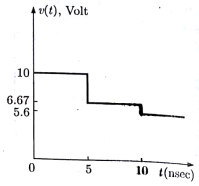
(B)


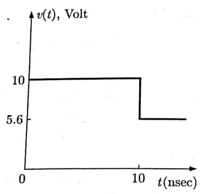
(C)


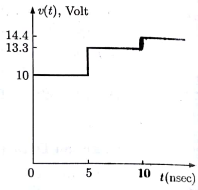
(D)


MCQ 8.1.27 The instantaneous voltage waveform $v(t)$ at the sending end of the transmission line will be

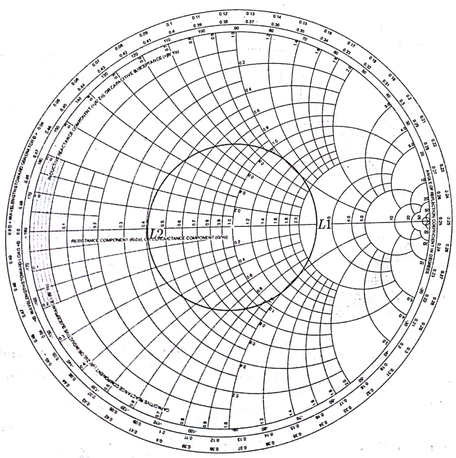
(A)


(B)


(C)


(D)


MCQ 8.1.28 The SWR circle 'L_1L_2' is shown on the smith chart for a lossless transmission line.



If line is terminated in a load $Z_L = 50\,\Omega$ then the possible value of the characteristic impedance of the line will be

(A) $125\,\Omega$ (B) $250\,\Omega$

(C) $20\,\Omega$ (D) (A) and (C) Both

Common Data For Q. 29 to 32 :

A lossless transmission line characterized by $Z_0 = 100\,\Omega$ is terminated in a load $Z_L = (100 + j50)\,\Omega$

MCQ 8.1.29 The reflection coefficient of the line will be

(A) $4.4e^{-j7.6^\circ}$ (B) $0.24e^{j76^\circ}$

(C) $4.4e^{j76^\circ}$ (D) $0.24e^{j76^\circ}$

MCQ 8.1.30 The input impedance at a distance of 0.35λ from the load will be

(A) $(0.61 - j0.22)\,\Omega$ (B) $(61 + j2.2)\,\Omega$

(C) $(61 - j2.2)\,\Omega$ (D) $(0.61 + j0.022)\,\Omega$

MCQ 8.1.31 The shortest length of the transmission line for which the input impedance appears to be purely resistive will be

(A) 0.25λ (B) 0.456λ

(C) 0.106λ (D) 0.544λ

MCQ 8.1.32 The first voltage maximum will occur at a distance of

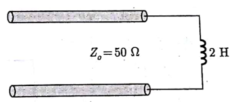
(A) 0.106λ from load

(B) 0.144λ from load

(C) 0.106λ from Generator

(D) 0.144λ from generator

MCQ 8.1.33 A transmission line of characteristic impedance $50\,\Omega$ is terminated by an inductor as shown in the figure.



A positive wave with constant voltage $V_0 = 1$ volt is incident on the load terminal at $t = 0$. At any time t the resulting negative wave voltage at the load terminal will be

(A) $(1 - 2e^{-25t})$ Volt (B) $(2e^{-25t} - 1)$ Volt

(C) $2e^{-25t}$ Volt (D) $(e^{-25t} - 1)$ Volt

MCQ 8.1.34 A transmission line has the characteristic impedance Z_0 and the voltage standing wave ratio is S. The line impedance on the transmission line at voltage maximum and minimum are respectively.

(A) $Z_0S, \frac{Z_0}{S}$ (B) $\frac{Z_0}{S}, Z_0S$

(C) Z_0S, Z_0S (D) $\frac{Z_0}{S}, \frac{Z_0}{S}$

MCQ 8.1.35 Consider the three mediums of intrinsic impedances η_1, η_2 and η_3 respectively as shown in the figure. What will be the thickness 't' and intrinsic impedance 'η_2' of the medium 2 for which the reflected wave having wavelength 'λ' is eliminated in medium 1 are

	thickness 't'	intrinsic impedance η_2
(A)	$\lambda/4$	$\sqrt{\eta_1\eta_3}$
(B)	$\lambda/2$	$\sqrt{\eta_1/\eta_3}$
(C)	$\lambda/4$	$\sqrt{\eta_1/\eta_3}$
(D)	$\lambda/2$	$\sqrt{\eta_1\eta_3}$

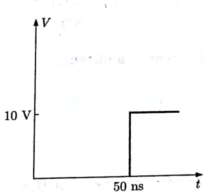
MCQ 8.1.36 A transmission line has characteristics impedance $100\,\Omega$ and standing wave ratio 3. The distance between the first voltage maximum and load is 0.125λ. Load impedance of the transmission line is

(A) $(30 + j40)\,\Omega$ (B) $(60 + j80)\,\Omega$

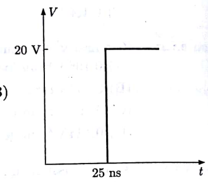
(C) $(30 - j40)\,\Omega$ (D) $(60 - j80)\,\Omega$

MCQ 8.1.37 A $100\,\Omega$ lossless transmission line with it's parameter $L' = 0.25\,\mu$H/m and $C' = 100$ PF/m is terminated by it's characteristic impedance. A 15 V voltage source with internal resistance $50\,\Omega$ is connected to the transmission line at $t = 0$. Plot of the voltage on the line at a distance 5 m from the source against time will be

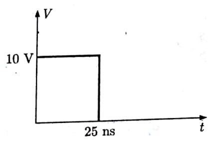
(A)



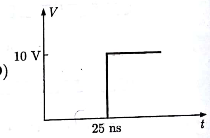
(B)



(C)



(D)



MCQ 8.1.38 A lossless transmission line terminated by a load impedance $Z_L \neq Z_0$ is connected to a D.C. voltage source. The height of the first forward voltage pulse is V_1^+. If the voltage reflection coefficients at the load and source are respectively Γ_L and Γ_g then the steady state voltage across the load is

(A) $V_1^+\left[\frac{1+\Gamma_L}{1-\Gamma_L}\right]$ (B) $V_1^+\left(\frac{1-\Gamma_g\Gamma_L}{1+\Gamma_L}\right)$

(C) $V_1^+\left(\frac{1-\Gamma_L}{1+\Gamma_L}\right)$ (D) $V_1^+\left(\frac{1+\Gamma_L}{1-\Gamma_g\Gamma_L}\right)$

****

EXERCISE 8.2

QUES 8.2.1 A transmission line is formed of coaxial line with an inner conductor diameter of 1 cm and an outer conductor diameter of 2 cm. If the conductor has permeability $\mu_c = 2\mu_o$ and conductivity $\sigma_c = 11.6 \times 10^7$ S/m then it's resistance per unit length for the operating frequency of 4 GHz will be ____ Ω/m.

QUES 8.2.2 A transmission line formed of co-axial line with inner and outer diameters 1.5 cm and 3 cm respectively is filled with a dielectric of permeability $\mu = 2\mu_0$. It's line parameter L' will be equal to ____ nH/m.

QUES 8.2.3 A co-axial transmission line is filled with a dielectric having conductivity, $\sigma = 2 \times 10^{-3}$ S/m. If the inner and outer radius of the co-axial line are 1/8 cm and 1/2 cm respectively then the conductance per unit length of the transmission line will be ____ mS/m

QUES 8.2.4 If permittivity of the dielectric filled inside the coaxial transmission line having inner and outer diameter 1 cm and 4 cm respectively is $\varepsilon = 9\varepsilon_0$ then the capacitance per unit length of the line will be ____ pF/m.

QUES 8.2.5 A parallel plate transmission line consists of 2.4 cm wide conducting strips having conductivity, $\sigma = 1.16 \times 10^8$ S/m and permeability $\mu = \mu_0$ is operating at 4 GHz frequency. What will be the line parameter R' (in Ω/m)?

QUES 8.2.6 A parallel plate transmission line is formed by copper strips of width $w = 4.8$ cm separated by a distance $d = 0.3$ cm. If the dielectric filled between the plates has permeability, $\mu = 2\mu_0$ then what will be the inductance per unit length (nH/m) of the transmission line ?

QUES 8.2.7 A 1 GHz parallel plate transmission line consists of brass strips of conductivity $\sigma = 6.4 \times 10^7$ S/m separated by a dielectric of permittivity $\varepsilon = 6\varepsilon_0$. If the axial component and transverse component of the electric field in the transmission line is E_z and E_y respectively then E_z/E_y equals to ____ $\times 10^{-5}$.

QUES 8.2.8 After traveling a distance of 20 m along a transmission line, the voltage wave remains 13 % of it's source amplitude. What is the attenuation constant (NP/m) of the transmission line ?

QUES 8.2.9 Amplitude of a voltage wave after travelling a certain distance down a transmission line is reduced by 87 %. If the propagation constant of the transmission line is $(0.5 + j2.4)$ then the phase shift in the voltage wave is ____ degrees.

QUES 8.2.10 A transmission line operating at 5 GHz frequency has characteristic impedance $Z_0 = 80\ \Omega$ and the phase constant $\beta = 1.5$ rad/m. The inductance per unit length of the transmission line will be ____ nH/m.

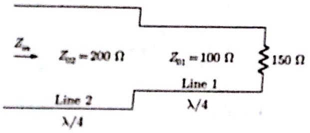
QUES 8.2.11 The voltage wave in a lossless transmission line has the maximum magnitude of 6 volt and minimum magnitude of 2.4 volt. The reflection coefficient of the transmission line is ____

QUES 8.2.12 An insulating material of permittivity $\varepsilon = 9\varepsilon_0$ is used in a $25\ \Omega$ lossless co-axial line. If the inner radius of the coaxial line is 0.6 mm then what will be it's outer radius (in mm) ?

QUES 8.2.13 A lossless transmission line of characteristic impedance $Z_0 = 25\ \Omega$ is connected to a load impedance $Z_L = (15 - j25)\ \Omega$. What will be the standing wave ratio on the line ?

QUES 8.2.14 A lossless transmission line is operating at a frequency of 2 MHz. When the line is short circuited at it's output end, the input impedance appears to be equivalent to an inductor with inductance of 32 nH but when the line is open circuited at it's output end, the input impedance appears to be equivalent to a capacitor with capacitance of 20 pF. What is the characteristic impedance (in Ω) of the transmission line ?

QUES 8.2.15 A $\lambda/4$ section of a $100\ \Omega$ lossless transmission line terminated in a $150\ \Omega$ resistive load is preceded by another $\lambda/4$ section of a $200\ \Omega$ lossless line as shown in figure. What is the input impedance, Z_{in} (in Ω)?



Common Data For Q. 16 and 17:

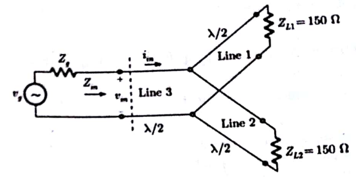
A load impedance $Z_L = (0.3 - j0.5)\ \text{k}\Omega$ is being connected to a lossless transmission line of characteristic impedance $Z_0 = 0.5\ \text{k}\Omega$ operating at wavelength $\lambda = 4$ cm.

QUES 8.2.16 What will be the distance (in cm) of the first voltage maximum from the load ?

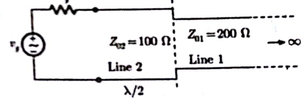
QUES 8.2.17 The distance of the first current maximum from the load will be ____ cm.

QUES 8.2.18 A voltage generator $V_g = 150$ V with an internal resistance $Z_g = 100\ \Omega$ is connected to a load $Z_L = 150\ \Omega$ through a 0.15λ section of a $100\ \Omega$ lossless transmission line. What is the average power (in watt) delivered to the transmission line ?

QUES 8.2.19 A voltage generator $V_g = 500$ volt with an internal resistance $Z_g = 100\ \Omega$ is applied to a configuration of lossless transmission lines as shown in figure. The power delivered to the load Z_{L1} will be ____ watt.

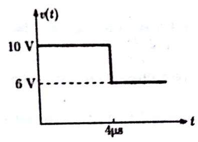


QUES 8.2.20 An infinitely long lossy transmission line with characteristic impedance $Z_{01} = 200\ \Omega$ is feeded by a $\lambda/2$ section of $100\ \Omega$ lossless transmission line as shown in figure. If a voltage generator $V_g = 4$ V with an internal resistance $Z_g = 100\ \Omega$ is applied to the whole configuration then the average power transmitted to the infinite transmission line will be ____ mW.



Common Data For Q. 21 and 22 :

A unit step voltage generator is applied to a $100\ \Omega$ airspaced lossless transmission line at time, $t = 0$. At any time, $t \geq 0$ the voltage waveform at the sending end of the transmission line is shown in the figure below :



QUES 8.2.21 The length of the transmission line will be ____ meter.

QUES 8.2.22 The unit step generator voltage connected to the line has an internal resistance $R_g = 100\,\Omega$. What will be the load impedance (in Ω) connected to the transmission line ?

Common Data For Q. 23 and 24 :

A quarter wave dielectric of thickness 't' and permittivity 'ε' eliminates reflections of uniform plane waves of frequency 1.5 GHz incident normally from free space onto a dielectric of permittivity $16\varepsilon_0$. (Assume all media to have $\mu = \mu_0$)

QUES 8.2.23 The relative permittivity of the dielectric coating equals to ____

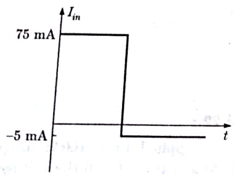
QUES 8.2.24 What is the thickness 't' (in cm) of the dielectric coating ?

QUES 8.2.25 A $60\,\Omega$ transmission line, terminated by a load of $180\,\Omega$ is connected to a 100 V DC source at $t = 0$. The internal resistance of the source is $120\,\Omega$. The steady state voltage across the load will be ____ volt.

QUES 8.2.26 At $t = 0$ a 50 Volt D.C. source with an internal resistance $30\,\Omega$ is connected to a transmission line of $15\,\Omega$ characteristic impedance having a load of $45\,\Omega$. The steady state load current for the transmission line is ____ Ampere.

Common Data For Q. 27 and 28 :

A transmission line of an unknown length terminated in a resistance is connected to a 6 V battery with zero internal resistance. The plot of input current to the line is shown in the figure below



QUES 8.2.27 The characteristic impedance of the transmission line will be ____ Ω

QUES 8.2.28 The load resistance terminated to the transmission line will be ____ Ω

****

EXERCISE 8.3

MCQ 8.3.1 Which one of the following statement is not correct for a transmission line ?

(A) Attenuation constant of a lossless line is always zero.

(B) Characteristic impedance of both lossless and distortionless line is real

(C) Attenuation constant of a distortionless line is always zero.

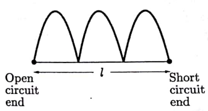
(D) Both (A) and (C).

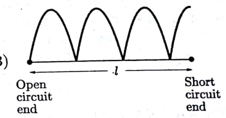
MCQ 8.3.2 The wavelength on a lossless transmission line terminated in a short circuit is λ. What is the minimum possible length of the transmission line for which it appears as an open circuit at it's input terminals ?

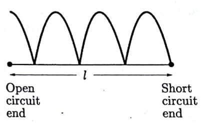
(A) λ (B) $\lambda/2$

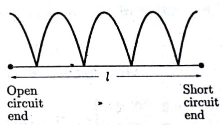
(C) 4λ (D) $\lambda/4$

MCQ 8.3.3 A transmission line of length l is short circuited at one end and open circuited at the other end. The voltage standing wave pattern in the transmission line will be

(A)


(B)


(C)


(D)


MCQ 8.3.4 A lossless transmission line is terminated in a short circuit. The minimum possible length of the line for which it appears as a short circuit at its input terminals is

(A) $\lambda/2$ (B) $\lambda/4$

(C) λ (D) 0

MCQ 8.3.5 If the load impedance in a transmission line is $100 + j200\,\Omega$ and characteristic impedance is $100\,\Omega$, the normalised load impedance is

(A) $1 + j2\,\Omega$

(B) $10000 + j20000\,\Omega$

(C) $1 + j200\,\Omega$

(D) $100 + j2\,\Omega$

MCQ 8.3.6 If the load impedance in a transmission line is z_L and z_0 is the characteristic impedance, reflection coefficient is

(A) $\frac{(z_L - z_0)}{(z_L + z_0)}$ (B) $\frac{(z_L + z_0)}{(z_L - z_0)}$

(C) $\frac{z_L}{z_0}$ (D) $\frac{z_0}{z_L}$

****

EXERCISE 8.4

MCQ 8.4.1 A coaxial-cable with an inner diameter of 1 mm and outer diameter of 2.4 mm is filled with a dielectric of relative permittivity 10.89. Given $\mu_0 = 4\pi \times 10^{-7}$ H/m, $\varepsilon_0 = \frac{10^{-9}}{36\pi}$ F/m, the characteristic impedance of the cable is

(A) 330 Ω (B) 100 Ω

(C) 143.3 Ω (D) 43.4 Ω

MCQ 8.4.2 A transmission line with a characteristic impedance of 100 Ω is used to match a 50 Ω section to a 200 Ω section. If the matching is to be done both at 429 MHz and 1 GHz, the length of the transmission line can be approximately

(A) 82.5 cm (b) 1.05 m

(C) 1.58 cm (D) 1.75 m

MCQ 8.4.3 A transmission line of characteristic impedance 50 Ω is terminated by a 50 Ω load. When excited by a sinusoidal voltage source at 10 GHz, the phase difference between two points spaced 2 mm apart on the line is found to be $\pi/4$ radians. The phase velocity of the wave along the line is

(A) 0.8×10^8 m/s (B) 1.2×10^8 m/s

(C) 1.6×10^8 m/s (D) 3×10^8 m/s

MCQ 8.4.4 A transmission line of characteristic impedance 50 Ω is terminated in a load impedance Z_L. The VSWR of the line is measured as 5 and the first of the voltage maxima in the line is observed at a distance of $\lambda/4$ from the load. The value of Z_L is

(A) 10 Ω (B) 250 Ω

(C) $(19.23 + j46.15)$ Ω (D) $(19.23 - j46.15)$ Ω

MCQ 8.4.5 If the scattering matrix $[S]$ of a two port network is $[S] = \begin{bmatrix} 0.2\angle 0^\circ & 0.9\angle 90^\circ \\ 0.9\angle 90^\circ & 0.1\angle 90^\circ \end{bmatrix}$, then the network is

(A) lossless and reciprocal

(B) lossless but not reciprocal

(C) not lossless but reciprocal

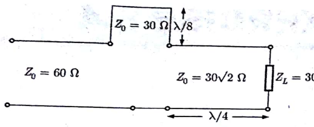
(D) neither lossless nor reciprocal

MCQ 8.4.6 A transmission line has a characteristic impedance of 50 Ω and a resistance of 0.1 Ω/m. If the line is distortion less, the attenuation constant(in Np/m) is

(A) 500 (B) 5

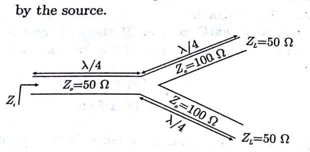
(C) 0.014 (D) 0.002

MCQ 8.4.7 In the circuit shown, all the transmission line sections are lossless. The Voltage Standing Wave Ration(VSWR) on the 60 Ω line is



(A) 1.00
(B) 1.64
(C) 2.50
(D) 3.00

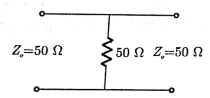
MCQ 8.4.8 A transmission line terminates in two branches, each of length $\frac{\lambda}{4}$, as shown. The branches are terminated by $50\ \Omega$ loads. The lines are lossless and have the characteristic impedances shown. Determine the impedance Z_i as seen by the source.



(A) $200\ \Omega$
(B) $100\ \Omega$
(C) $50\ \Omega$
(D) $25\ \Omega$

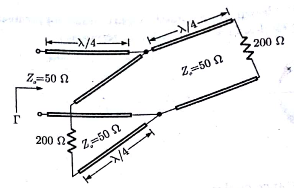
MCQ 8.4.9 One end of a loss-less transmission line having the characteristic impedance of $75\ \Omega$ and length of 1 cm is short-circuited. At 3 GHz, the input impedance at the other end of transmission line is
(A) 0
(B) Resistive
(C) Capacitive
(D) Inductive

MCQ 8.4.10 A load of $50\ \Omega$ is connected in shunt in a 2-wire transmission line of $Z_0 = 50\Omega$ as shown in the figure. The 2-port scattering parameter matrix (S-matrix) of the shunt element is



(A) $\begin{bmatrix} -\frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} \end{bmatrix}$
(B) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$
(C) $\begin{bmatrix} -\frac{1}{3} & \frac{2}{3} \\ \frac{2}{3} & -\frac{1}{3} \end{bmatrix}$
(D) $\begin{bmatrix} \frac{1}{4} & -\frac{3}{4} \\ -\frac{3}{4} & \frac{1}{4} \end{bmatrix}$

MCQ 8.4.11 The parallel branches of a 2-wire transmission line are terminated in $100\ \Omega$ and $200\ \Omega$ resistors as shown in the figure. The characteristic impedance of the line is $Z_0 = 50\ \Omega$ and each section has a length of $\frac{\lambda}{4}$. The voltage reflection coefficient Γ at the input is



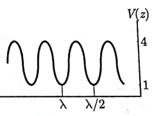
(A) $-j\frac{7}{5}$
(B) $\frac{-5}{7}$
(C) $j\frac{5}{7}$
(D) $\frac{5}{7}$

MCQ 8.4.12 A transmission line is feeding 1 watt of power to a horn antenna having a gain of 10 dB. The antenna is matched to the transmission line. The total power radiated by the horn antenna into the free space is
(A) 10 Watts
(B) 1 Watts
(C) 0.1 Watts
(D) 0.01 Watt

MCQ 8.4.13 Characteristic impedance of a transmission line is $50\ \Omega$. Input impedance of the open circuited line is $Z_{oc} = 100 + j150\ \Omega$. When the transmission line is short circuited, then value of the input impedance will be
(A) $50\ \Omega$
(B) $100 + j150\ \Omega$
(C) $7.69 + j11.54\ \Omega$
(D) $7.69 - j11.54\ \Omega$

Common Data For Q. 14 to 15 :

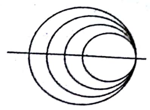
Voltage standing wave pattern in a lossless transmission line with characteristic impedance 50 and a resistive load is shown in the figure.



MCQ 8.4.14 The value of the load resistance is
(A) 50 Ω
(B) 200 Ω
(C) 12.5 Ω
(D) 0

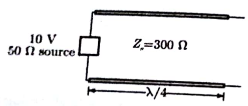
MCQ 8.4.15 The reflection coefficient is given by
(A) −0.6
(B) −1
(C) 0.6
(D) 0

MCQ 8.4.16 Many circles are drawn in a Smith Chart used for transmission line calculations. The circles shown in the figure represent



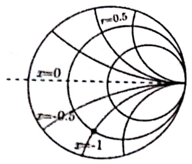
(A) Unit circles
(B) Constant resistance circles
(C) Constant reactance circles
(D) Constant reflection coefficient circles.

MCQ 8.4.17 Consider a 300 Ω, quarter - wave long (at 1 GHz) transmission line as shown in Fig. It is connected to a 10 V, 50 Ω source at one end and is left open circuited at the other end. The magnitude of the voltage at the open circuit end of the line is



(A) 10 V
(B) 5 V
(C) 60 V
(D) 60/7 V

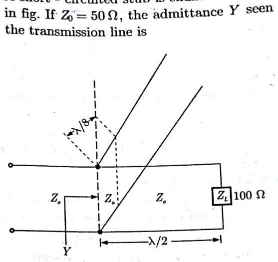
MCQ 8.4.18 Consider an impedance $Z = R + jX$ marked with point P in an impedance Smith chart as shown in Fig. The movement from point P along a constant resistance circle in the clockwise direction by an angle 45° is equivalent to



(A) adding an inductance in series with Z
(B) adding a capacitance in series with Z
(C) adding an inductance in shunt across Z
(D) adding a capacitance in shunt across Z

MCQ 8.4.19 A lossless transmission line is terminated in a load which reflects a part of the incident power. The measured VSWR is 2. The percentage of the power that is reflected back is
(A) 57.73
(B) 33.33
(C) 0.11
(D) 11.11

MCQ 8.4.20 A short - circuited stub is shunt connected to a transmission line as shown in fig. If $Z_0 = 50\,\Omega$, the admittance Y seen at the junction of the stub and the transmission line is



(A) (0.01 − j0.02) mho
(B) (0.02 − j0.01) mho
(C) (0.04 − j0.02) mho
(D) (0.02 + j0) mho

MCQ 8.4.21 The VSWR can have any value between
(A) 0 and 1
(B) −1 and +1
(C) 0 and ∞
(D) 1 and ∞

MCQ 8.4.22 In an impedance Smith chart, a clockwise movement along a constant resistance circle gives rise to
(A) a decrease in the value of reactance
(B) an increase in the value of reactance
(C) no change in the reactance value
(D) no change in the impedance

MCQ 8.4.23 A transmission line is distortionless if
(A) $RL = \frac{1}{GC}$
(B) $RL = GC$
(C) $LG = RC$
(D) $RG = LC$

MCQ 8.4.24 The magnitudes of the open-circuit and short-circuit input impedances of a transmission line are 100 Ω and 25 Ω respectively. The characteristic impedance of the line is,
(A) 25 Ω
(B) 50 Ω
(C) 75 Ω
(D) 100 Ω

MCQ 8.4.25 In a twin-wire transmission line in air, the adjacent voltage maxima are at 12.5 cm and 27.5 cm. The operating frequency is
(A) 300 MHz
(B) 1 GHz
(C) 2 GHz
(D) 6.28 GHz

MCQ 8.4.26 In air, a lossless transmission line of length 50 cm with $L = 10\,\mu$H/m, $C = 40$ pF/m is operated at 25 MHz. Its electrical path length is
(A) 0.5 meters
(B) λ meters
(C) π/2 radians
(D) 180 degrees

MCQ 8.4.27 A transmission line of $50\,\Omega$ characteristic impedance is terminated with a $100\,\Omega$ resistance. The minimum impedance measured on the line is equal to

(A) $0\,\Omega$ (B) $25\,\Omega$

(C) $50\,\Omega$ (D) $100\,\Omega$

MCQ 8.4.28 A very lossy, $\lambda/4$ long, $50\,\Omega$ transmission line is open circuited at the load end. The input impedance measured at the other end of the line is approximately

(A) 0 (B) $50\,\Omega$

(C) ∞ (D) None of the above

MCQ 8.4.29 A lossless transmission line having $50\,\Omega$ characteristic impedance and length $\lambda/4$ is short circuited at one end and connected to an ideal voltage source of 1 V at the other end. The current drawn from the voltage source is

(A) 0 (B) 0.02 A

(C) ∞ (D) none of these

MCQ 8.4.30 The capacitance per unit length and the characteristic impedance of a lossless transmission line are C and Z_0 respectively. The velocity of a travelling wave on the transmission line is

(A) $Z_0 C$ (B) $\frac{1}{Z_0 C}$

(C) $\frac{Z_0}{C}$ (D) $\frac{C}{Z_0}$

MCQ 8.4.31 A $\lambda/4$ line, shorted at one end, presents impedance at the other end equal to

(A) Z_0 (B) $\sqrt{2}\,Z_0$

(C) ∞ (D) 0

where Z_0 is characteristic impedance of the line.

MCQ 8.4.32 A $75\,\Omega$ transmission line is first short-terminated and the minima locations are noted. When the short is replaced by a resistive load R_L, the minima locations are not altered and the VSWR is measured to be 3. The value of R_L is

(A) $25\,\Omega$ (B) $50\,\Omega$

(C) $225\,\Omega$ (D) $250\,\Omega$

MCQ 8.4.33 If maximum and minimum voltage on a transmission line are 4 V and 2 V respectively, VSWR is

(A) 0.5 (B) 2

(C) 1 (D) 8

MCQ 8.4.34 An ideal lossless transmission line of $Z_0 = 60\,\Omega$ is connected to unknown Z_L. If $SWR = 4$, find Z_L.

(A) $240\,\Omega$ (B) $480\,\Omega$

(C) $120\,\Omega$ (D) $100\,\Omega$

MCQ 8.4.35 Loading of a cable is done to

1. Increase its inductance
2. Increase its leakage resistance
3. Decrease its leakage resistance
4. Achieve distortionless condition

(A) 1, 2, 3 and 4

(B) 1 and 3 only

(C) 2 and 3 only

(D) 1 and 4 only

MCQ 8.4.36 Given a range of frequencies, which of the following systems is best for transmission line load matching ?

(A) Single stub

(B) Double stub

(C) Single stub with adjustable position

(D) Quarter wave transformer

MCQ 8.4.37 A line of characteristic impedance $50\,\Omega$ is terminated at one end by $+j50\,\Omega$. The VSWR on the line is

(A) 1 (B) ∞

(C) 0 (D) j

MCQ 8.4.38 At UHF short-circuited lossless transmission lines can be used to provide appropriate values of impedance. Match **List I** with **List II** and select the correct answer using the code given below the lists :

	List I		**List II**
a.	$l < \lambda/4$	**1.**	Capacitive
b.	$\lambda/4 < l < \lambda/2$	**2.**	Inductive
c.	$l = \lambda/4$	**3.**	0
d.	$l = \lambda/2$	**4.**	∞

Codes :

	a	b	c	d
(A)	2	1	4	3
(B)	3	1	4	2
(C)	2	4	1	3
(D)	3	4	1	2

MCQ 8.4.39 Consider the following statements regarding a transmission line :

1. Its attenuation is constant and is independent of frequency
2. Its attenuation varies linearly with frequency
3. Its phase shift varies linearly with frequency
4. Its phase shift is constant and is independent of frequency

Which of the above statements are correct for distortion less line ?

(A) 1, 2, 3, and 4

(B) 2 and 3 only

(C) 1 and 3 only

(D) 3 and 4 only

MCQ 8.4.40 The reflection coefficient on a 500 m long transmission line has a phase angle of $-150°$. If the operating wavelength is 150 m, what will be the number of voltage maxima on the line ?

(A) 0 (B) 3

(C) 6 (D) 7

MCQ 8.4.41 With regard to a transmission line, which of the following statements is correct ?
(A) Any impedance repeats itself every $\lambda/4$ on the Smith chart.
(B) The SWR $= 2$ circle and the magnitude of reflection coefficient $= 0.5$ circle coincide on the Smith chart.
(C) At any point on a transmission line, the current reflection coefficient is the reciprocal of the voltage reflection coefficient.
(D) Matching eliminates the reflected wave between the source and the matching device location.

MCQ 8.4.42 It is required to match a $200\,\Omega$ load to a $450\,\Omega$ transmission line. To reduce the SWR along the line to 1, what must be the characteristic impedance of the quarter-wave transformer used for this purpose, if it is connected directly to the load ?
(A) $90\text{ k}\Omega$ (B) $300\,\Omega$
(C) $\frac{9}{4}\,\Omega$ (D) $\frac{3}{2}\,\Omega$

MCQ 8.4.43 The load end of a quarter wave transformer gets disconnected thereby causing an open-circuited load. What will be the input impedance of the transformer ?
(A) Zero
(B) Infinite
(C) Finite and positive
(D) Finite and negative

MCQ 8.4.44 A lossless transmission line of characteristic impedance Z_0 and length $l < \lambda/4$ is terminated at the load end by an open circuit. What is its input impedance Z_{in}?
(A) $Z_{in} = jZ_0 \tan \beta l$
(B) $Z_{in} = jZ_0 \cot \beta l$
(C) $Z_{in} = -jZ_0 \tan \beta l$
(D) $Z_{in} = -jZ_0 \tan \beta l$

MCQ 8.4.45 Which one of the following statements for a short circuited loss free line is not correct ?
(A) The line appears as a pure reactance when viewed from the sending end
(B) It can be either inductive or capacitive
(C) There are no reflections in the line
(D) Standing waves of voltage and current are set up along length of the lines

MCQ 8.4.46 Match List I (Load impedance) with List II (Value of Reflection Coefficient) and select the correct answer using the code given below the lists :

	List-I		List-II
a.	Short Circuit	1.	0
b.	Open Circuit	2.	-1
c.	Line characteristics impedance	3.	$+1$
d.	$2\times$ line characteristic impedance	4.	$+1/3$

Codes :

	a	b	c	d
(A)	2	1	3	4
(B)	4	3	1	2
(C)	2	3	1	4
(D)	4	1	3	2

MCQ 8.4.47 When the reflection coefficient equals $1\underline{/0^\circ}$ what is the VSWR?
(A) Zero (B) 1
(C) 3 (D) Infinite

MCQ 8.4.48 If the reflection coefficient is 1/5, what is the corresponding VSWR ?
(A) 3/2 (B) 2/3
(C) 5/2 (D) 2/5

MCQ 8.4.49 Which one of the following is the characteristic impedance of lossless transmission line ?
(A) $\sqrt{R/G}$ (B) $\sqrt{L/G}$
(C) $\sqrt{L/C}$ (D) $\sqrt{R/C}$

MCQ 8.4.50 Match List I (Quantity) with List II (Range of Values) and select the correct answer using the code given below the lists :

	List-I		List-II
a.	Input Impedance	1.	-1 to $+1$
b	Reflection coefficient	2.	1 to ∞
c.	VSWR	3.	0 to ∞

Codes :

	a	b	c
(A)	2	3	1
(B)	3	2	1
(C)	3	1	2
(D)	2	1	3

MCQ 8.4.51 A quarter wave impedance transformer is terminated by a short circuit. What would its input impedance be equal to ?
(A) The line characteristic impedance
(B) Zero
(C) Infinity
(D) Square root of the line characteristic impedance

MCQ 8.4.52 Scattering parameters are more suited than impedance parameters to describe a waveguide junction because
(A) the scattering parameters are frequency invariant whereas the impedance parameters are not so
(B) scattering matrix is always unitary
(C) impedance parameters vary over unacceptably wide ranges
(D) scattering parameters are directly measurable but impedance parameters are not so

MCQ 8.4.53 In a transmission line the reflection coefficient at the load end is given by $0.3e^{-j30^\circ}$. What is the reflection coefficient at a distance of 0.1 wavelength towards source ?

(A) $0.3e^{+j30^\circ}$
(B) $0.3e^{+j102^\circ}$
(C) $0.3e^{+j258^\circ}$
(D) $0.3e^{+66^\circ}$

MCQ 8.4.54 To couple a coaxial line to a parallel wire, it is best to use a :

(A) Balun
(B) Slotted line
(C) Directional coupler
(D) Quarter wave transformer

MCQ 8.4.55 A plane wave having x-directed electric field propagating in free space along the z-direction is incident on an infinite electrically conducting (perfect conductor) sheet at $z = 0$ plane. Which one of the following is correct ?

(A) The sheet will absorb the wave
(B) There will be x-directed surface electric current on the sheet
(C) There will be y-directed surface electric current on the sheet
(D) There will be magnetic current in the sheet.

MCQ 8.4.56 For sea water with $\sigma = 5$ mho/m and $\varepsilon_r = 80$, what is the distance for which radio signal can be transmitted with 90% attenuation at 25 kHz ?

(A) 0.322 m
(B) 3.22 m
(C) 32.2 m
(D) 322 m

MCQ 8.4.57 Consider the following statements regarding Smith charts :

1. A normalized Smith chart applies to a line of any characteristic resistance and serves as well for normalized admittance
2. A polar coordinate Smith chart contains circles of constant $|z|$ and circles of constant $\underline{/z}$
3. In Smith chart, the distance towards the load is always measured in clockwise direction.

Which of the statements given above are correct ?

(A) 1, 2 and 3
(B) 2 and 3
(C) 1 and 3
(D) 1 and 2

MCQ 8.4.58 A $(100 - j75)\,\Omega$ load is connected to a co-axial cable of characteristic impedance 75 ohms at 12 GHz. In order to obtain the best matching, which one of the following will have to be connected ?

(A) A short-circuited sub at load
(B) Inductance at load
(C) A capacitance at a specific distance at load
(D) A short-circuited stub at some specific distance from load

MCQ 8.4.59 In a line VSWR of a load is 6 dB. The reflection coefficient will be

(A) 0.033
(B) 0.33
(C) 0.66
(D) 3.3

MCQ 8.4.60 $Z_L = 200\,\Omega$ and it is desired that $Z_{in} = 50\,\Omega$. The quarter wave transformer should have a characteristic impedance of

(A) 100 Ω
(B) 40 Ω
(C) 10,000 Ω
(D) 4 Ω

MCQ 8.4.61 Consider the following :
For a lossless transmission line we can write :

1. $Z_{in} = -jZ_0$ for a shorted line with $l = \lambda/8$
2. $Z_{in} = \pm j\alpha$ for a shorted line with $l = \lambda/4$
3. $Z_{in} = Z_0$ for a matched line of any length

Select the correct answer using the codes given below :

(A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 2 and 4

MCQ 8.4.62 The input impedance of a short circuited quarter wave long transmission line is

(A) purely reactive
(B) purely resistive
(C) dependent on the characteristic impedance of the line
(D) none of the above

MCQ 8.4.63 A transmission line of output impedance $400\,\Omega$ is to be matched to a load of $25\,\Omega$ through a quarter wavelength line. The quarter wave line characteristic impedance must be

(A) $40\,\Omega$
(B) $100\,\Omega$
(C) $400\,\Omega$
(D) $425\,\Omega$

MCQ 8.4.64 The input impedance of $\lambda/8$ long short-circuited section of a lossless transmission line is

(A) zero
(B) inductive
(C) capacitive
(D) infinite

MCQ 8.4.65 Match List I (Parameters) with List II (Values) for a transmission line with a series impedance $Z = R' + j\omega L'\,\Omega/\text{m}$ and a shunt admittance $Y = G' + j\omega C'$ mho/m, and select the correct answer :

List-I	List-II
a. Characteristic impedance Z_0	1. $\sqrt{ZY}$
b. Propagation constant γ	2. $\sqrt{Z/Y}$
c. The sending-end input impedance Z_{in} when the line is terminated in its characteristic impedance Z_0	3. $\sqrt{Y/Z}$

Codes :

	a	b	c
(A)	3	1	1
(B)	2	3	3
(C)	2	1	2
(D)	1	2	2

MCQ 8.4.66 Which of the following conditions will not guarantee a distortionless transmission line ?
(A) $R = G = 0$
(B) $RC = GL$
(C) Very low frequency range ($R >> \omega L, G >> \omega C$)
(D) Very high frequency range ($R << \omega L, G << \omega C$)

MCQ 8.4.67 In an air line, adjacent maxima are found at 12.5 cm and 37.5 cm. The operating frequency is
(A) 1.5 GHz
(B) 600 MHz
(C) 300 MHz
(D) 1.2 GHz

MCQ 8.4.68 Fig. I shows an open circuited transmission line. The switch is closed at time $t = 0$ and after a time t the voltage distribution on the line reaches that shown in Fig. II. If c is the velocity in the line, then

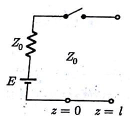


Figure I

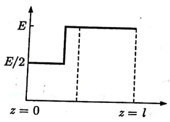


Figure II

(A) $t < l/c$
(B) $t = l/c$
(C) $1l/c > l/c$
(D) $t < 2l/c$

MCQ 8.4.69 A 75 Ω transmission line is first short-terminated and the minima locations are noted. When the short is replaced by a resistive load R_L, the minima locations are not altered and the VSWR is measured to be 3. The value of R_L is
(A) 25 Ω
(B) 50 Ω
(C) 225 Ω
(D) 250 Ω

MCQ 8.4.70 For a lossy transmission line, the characteristic impedance does not depend on
(A) the operating frequency of the line
(B) theconductivity of the conductors
(C) conductivity of the dielectric separating the conductors
(D) length of the line

MCQ 8.4.71 If the maximum and minimum voltages on a transmission line are 4 V and 2 V, respectively for a typical load, VSWR is
(A) 1.0
(B) 0.5
(C) 2.0
(D) 8.0

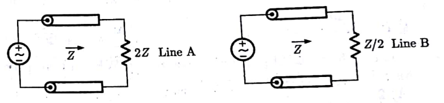
MCQ 8.4.72 A transmission line is distortionless if
(A) $RG = LC$
(B) $RC = GL$
(C) $\frac{R}{C} = \frac{G}{L}$
(D) $R = G$

MCQ 8.4.73 If reflection coefficient for voltage be 0.6, the voltage standing wave ratio (VSWR) is
(A) 0.66
(B) 4
(C) 1.5
(D) 2

MCQ 8.4.74 A signal of 10 V is applied to a 50 ohm coaxial transmission line, terminated in a 100 ohm load. The voltage reflected coefficient is
(A) 1/4
(B) 1/3
(C) 1/2
(D) 1

MCQ 8.4.75 A transmission line of characteristic impedance of 50 ohm is terminated by a load impedance of $(15 - j20)$ ohm. What is the normalized load impedance ?
(A) $0.6 - j0.8$
(B) $0.3 - j0.6$
(C) $0.3 - j0.4$
(D) $0.3 + j0.4$

MCQ 8.4.76 Two lossless resistive transmission lines each of characteristic impedance Z are connected as shown in the circuit below. If the maximum voltage on the two lines is the same and the power transmitted by line A is W_1, then what is the power transmitted by the line B ?



(A) $4W_1$
(B) $3W_1$
(C) $2W_1$
(D) $1W_1$

MCQ 8.4.77 A transmission line section shows an input impedance of 36 Ω and 64 Ω respectively, when short circuited and open circuited. What is the characteristic impedance of the transmission line ?
(A) 100 Ω
(B) 50 Ω
(C) 45 Ω
(D) 48 Ω

MCQ 8.4.78 Consider the following statements for transmission lines :
1. When a transmission line is terminated by its characteristic impedance the line will not have any reflected wave.
2. For a finite line terminated by its characteristic impedance the velocity and current at all points on the line are exactly same.
3. For a lossless half wave transmission line the input impedance is not equal to load impedance.

Which of the statements given above are correct ?
(A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 1, 2 and 3

MCQ 8.4.79 What does the standing wave ratio (SWR) of unity imply ?
(A) Transmission line is open circuited
(B) Transmission line is short circuited
(C) Transmission line's characteristic impedance is equal to load impedance
(D) Transmission line's characteristic impedance is not equal to load impedance

MCQ 8.4.80 $h =$ half centre to centre spacing, $r =$ conductor radius and $\varepsilon =$ permittivity of the medium. Which one of the following is equal to the capacitance per unit length of a two-wire transmission line ?
(A) $\dfrac{\pi\varepsilon}{\log_e\left\{\left(\frac{h}{r}\right)+\left(\sqrt{\frac{h^2}{r^2}-1}\right)\right\}}$
(B) $\dfrac{2\pi\varepsilon}{\log_e\left\{\left(\frac{h}{r}\right)+\left(\sqrt{\frac{h^2}{r^2}-1}\right)\right\}}$
(C) $\dfrac{3\pi\varepsilon}{\log_e\left\{\left(\frac{h}{r}\right)+\left(\sqrt{\frac{h^2}{r^2}-1}\right)\right\}}$
(D) $\dfrac{4\pi\varepsilon}{\log_e\left\{\left(\frac{h}{r}\right)+\left(\sqrt{\frac{h^2}{r^2}-1}\right)\right\}}$

MCQ 8.4.81 For a line of characteristic impedance Z_0 terminated in a load of Z_R such that $Z_R = Z_0/3$, what is the reflection coefficient Γ_L ?
(A) 1/3
(B) 2/3
(C) $-1/3$
(D) $-1/2$

MCQ 8.4.82 A transmission line has R, L, G, C distributed parameters per unit length of line. If γ is the propagation constant of the line, which one of the following expressions represents the characteristics impedance of the line ?
(A) $\dfrac{\gamma}{R+j\omega L}$
(B) $\dfrac{R+j\omega L}{\gamma}$
(C) $\dfrac{G+j\omega C}{\gamma}$
(D) $\sqrt{\dfrac{G+j\omega C}{R+j\omega L}}$

MCQ 8.4.83 What is the value of standing wave ratio (SWR) in free space for reflection for reflection coefficient $\Gamma = -1/3$
(A) 2/3
(B) 0.5
(C) 4.0
(D) 2.0

MCQ 8.4.84 What is the attenuation constant α for distortionless transmission line ?
(A) $\alpha = 0$
(B) $\alpha = R\sqrt{\dfrac{C}{L}}$
(C) $\alpha = R\sqrt{\dfrac{L}{C}}$
(D) $\alpha = \sqrt{\dfrac{RL}{C}}$

MCQ 8.4.85 A 50 Ω distortionless transmission line has a capacitance of 10^{-10} f/m. What is the inductance per meter ?
(A) 0.25 μH
(B) 500 μH
(C) 5000 μH
(D) 50 μH

MCQ 8.4.86 The open circuit and short circuit impedances of a line are 100 Ω each. What is the characteristic impedance of the line ?
(A) $100\sqrt{2}\,\Omega$
(B) 100Ω
(C) $100/\sqrt{2}\,\Omega$
(D) 50 Ω

MCQ 8.4.87 A load impedance of $(75 - j50)$ is connected to a transmission line of characteristic impedance $Z_0 = 75\,\Omega$. The best method of matching comprises
(A) A short circuit stub at load
(B) A short circuit stub at some specific distance from load
(C) An open stub at load
(D) Two short circuited stubs at specific distances from load

MCQ 8.4.88 When a lossless transmission line is terminated by a resistance equal to surge impedance, then what is value of the reflection coefficient ?
(A) 1
(B) -1
(C) 0
(D) 0.5

MCQ 8.4.89 A lossless transmission line of length 50 cm with $L = 10\,\mu\text{H/m}$, $C = 40\,\text{pF/m}$ is operated at 30 MHz. What is its electric length (βl) ?
(A) 20λ
(B) 0.2λ
(C) $108°$
(D) 40π

MCQ 8.4.90 Which one of the following is the correct expression for the propagation constant in a transmission line ?
(A) $\sqrt{\dfrac{(R+j\omega L)}{(G+j\omega C)}}$
(B) $\sqrt{\dfrac{(R-j\omega L)}{(G-j\omega C)}}$
(C) $(R-j\omega L)(G-j\omega C)$
(D) $\sqrt{(R+j\omega L)(G+j\omega C)}$

MCQ 8.4.91 **Assertion (A) :** In a lossless transmission line the voltage and current distributions along the line are always constant.
Reason (R) : The voltage and current distributions in an open line are such that at a distance $\lambda/4$ from the load end, the line looks like a series resonant circuit.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is NOT the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

MCQ 8.4.92 Consider the following statements :
Characteristic impedance of a transmission line is given by
1. $\sqrt{\dfrac{R+j\omega L}{G+j\omega C}}$, (R, L, G and C are line constants)
2. $\sqrt{Z_{oc}Z_{sc}}$, (Z_{oc} and Z_{sc} are the open and short circuit impedances of the line)
3. V'/I', (V' and I' are the voltage and current of the wave travelling in the positive y direction)

Which of these are correct ?
(A) 1,2 and 3
(B) 1 and 2
(C) 2 and 3
(D) 1 and 3

MCQ 8.4.93 A loss-less transmission line of characteristic impedance Z_0 and $l < \lambda/4$ is terminated at the load end by a short circuit. Its input impedance Z_s is
(A) $Z_s = -jZ_0 \tan\beta l$
(B) $Z_s = jZ_0 \cot\beta l$
(C) $Z_s = jZ_0 \tan\beta l$
(D) $Z_s = -jZ_0 \cot\beta l$

MCQ 8.4.94 A loss-less transmission line with characteristic impedance of 600 ohms is terminated in a purely resistive load of 900 ohms. The reflection coefficient is

(A) 0.2 (B) 0.5
(C) 0.667 (D) 1.5

MCQ 8.4.95 A transmission line has R, L, G and C distributed parameters per unit length of the line, γ is the propagation constant of the lines. Which expression gives the characteristic impedance of the line ?

(A) $\frac{\gamma}{R+j\omega L}$ (B) $\frac{R+j\omega L}{\gamma}$
(C) $\frac{G+j\omega C}{\gamma}$ (D) $\sqrt{\frac{G+j\omega C}{R+j\omega L}}$

MCQ 8.4.96 The open circuit impedance of a certain length of a loss-less line is 100 Ω. The short circuit impedance of the same line is also 100 Ω. The characteristic impedance of the line is

(A) $100\sqrt{2}$ Ω (B) 50 Ω
(C) $100/\sqrt{2}$ Ω (D) 100 Ω

MCQ 8.4.97 In the relations $S=\frac{1+|\Gamma|}{1-|\Gamma|}$; the values of S and Γ (where S stands for wave ratio and Γ is reflection coefficient), respectively, vary as

(A) 0 to 1 and −1 to 0 (B) 1 to ∞ and −1 to +1
(C) −1 to +1 and 1 to ∞ (D) −1 to 0 and 0 to 1

MCQ 8.4.98 Consider the following statements :

The characteristic impedance of a transmission line can increase with the increase in

1. resistance per unit length
2. conductance per unit length
3. capacitance per unit length
4. inductance per unit length

Which of these statements are correct ?

(A) 1 and 2 (B) 2 and 3
(C) 1 and 4 (D) 3 and 4

****

SOLUTIONS 8.1

SOL 8.1.1 Option (A) is correct.

Given

the input voltage, $v_i = V_0\cos(4\times 10^4\pi t)$

and length of transmission line, $l = 20\text{ cm} = 20\times 10^{-2}\text{ m}$

So, the angular frequency of the applied voltage is

$$\omega = 4\times 10^4\pi$$

and the wavelength of the voltage wave is

$$\lambda = \frac{v_p}{f} = \frac{2\pi v_p}{\omega} \qquad \left(f=\frac{\omega}{2\pi}\right)$$

Therefore, $$\frac{l}{\lambda} = \frac{\omega(20\times 10^{-2})}{2\pi v_p}$$

$$= \frac{(4\times 10^4\pi)\times(20\times 10^{-2})}{2\pi\times(3\times 10^8)} \quad \text{(in free space } v_p = 3\times 10^8\text{ m/s)}$$

$$= 1.33\times 10^{-5}$$

Since, $\frac{l}{\lambda} \le 0.01$

So the effect of transmission line on the voltage wave is negligible i.e. the output voltage will be in the same phase to the input voltage.

Thus, A and R both are true and R is correct explanation of A.

SOL 8.1.2 Option (C) is correct.

The width of strips, $w = 9.6\text{ cm} = 9.6\times 10^{-2}\text{ m}$

Separation between the strips, $d = 0.6\text{ cm} = 0.6\times 10^{-2}\text{ m}$

Relative permittivity of dielectric, $\varepsilon_r = 1.3$

Conductivity of dielectric, $\sigma \approx 0$

So, the conductance per unit length of line is given as

$$G' = \frac{\sigma w}{d} = 0 \qquad \sigma \approx 0$$

and the capacitance per unit length of the line is given as

$$C' = \frac{\varepsilon w}{d} = \varepsilon_0\varepsilon_r\frac{w}{d} = (8.85\times 10^{-12})\times 1.3\times\frac{9.6\times 10^{-2}}{0.6\times 10^{-2}}$$

$$= 1.84\times 10^{-10}\text{ F/m} = 0.18\text{ nF/m}$$

SOL 8.1.3 Option (C) is correct.

Inductance per unit length, $L' = 250\text{ nH/m} = 250\times 10^{-9}\text{ H/m}$

Capacitance per unit length $C' = 0.1\text{ nF/m} = 0.1\times 10^{-9}\text{ F/m}$

So, the velocity of wave propagation along the lossless transmission line is given as

$$v_p = \frac{1}{\sqrt{L'C'}} = \frac{1}{\sqrt{(250\times 10^{-9})(0.1\times 10^{-9})}}$$

$$= 2\times 10^8\text{ m/s}$$

The characteristic impedance of the lossless transmission line is given as